NASA TECH BRIEF
Goddard Space Flight Center

Active Tuning Circuit

The problem:

It is expensive and difficult to produce a microelectronic active tuning circuit that has a high Q (energy storage rating) at high frequencies. Such circuits require a low-loss substrate with a perfect surface finish (polished sapphire for example) and metallizations of proper resistivity and thickness with perfect geometrical definition. Furthermore, when inductors are used for selectivity and to match impedances, it is even more difficult to reduce the circuit to microelectronic form.

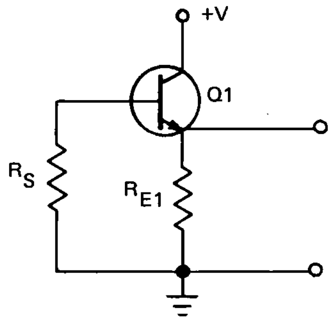

Figure 1. Inductor Circuit

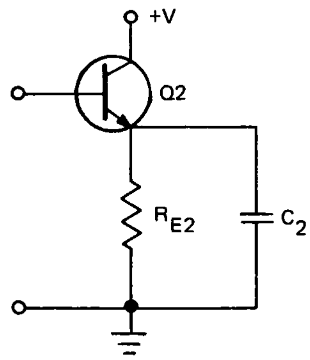

Figure 2. Negative-RC Circuit

The solution:

A low-cost, inductorless, high Q active-tuning circuit can be made by coupling a pair of transistors and their supporting circuitry to take advantage of frequency dependent energy storage effects.

How it's done:

Figure 1 is a circuit with a bipolar transistor. If operated near its transitional frequency (F_t), the transistor will exhibit inherent phase shifts caused by base transit-time effects. At frequencies close to F_t, the circuit in Figure 1 behaves as an RL circuit with a low Q. By combining this circuit with the negative-phase-capacitive circuit in Figure 2, an active tuning circuit with a high Q (100 to 200) is formed.

In the circuit shown in Figure 2, a capacitor is connected in parallel with the emitter bias lumped resistor. If the impedance of the emitter load is properly chosen, the input impedance into the base of the transistor will have a negative resistance and capacitive reactance near the transitional frequency. By connecting the negative resistance and capacitive reactance to the emitter circuit of the transistor in Figure 1, selective tuning and high Q's are made possible.

Figure 3 shows how the two circuits are combined for use with a signal and a load. An external signal source E_s, with a resistance R_s, is connected to the junction of a resistive divider and to the base of the first npn transistor Q1.

The frequency and phase of the circuit are adjusted by C1 and C2. This limit depends on the specific transistor type and the bias current.

Previous mathematical models were not useful in determining the operating characteristics of the circuit. Thus a new method has been devised to determine the upper-frequency limit. It is based on a measurement of

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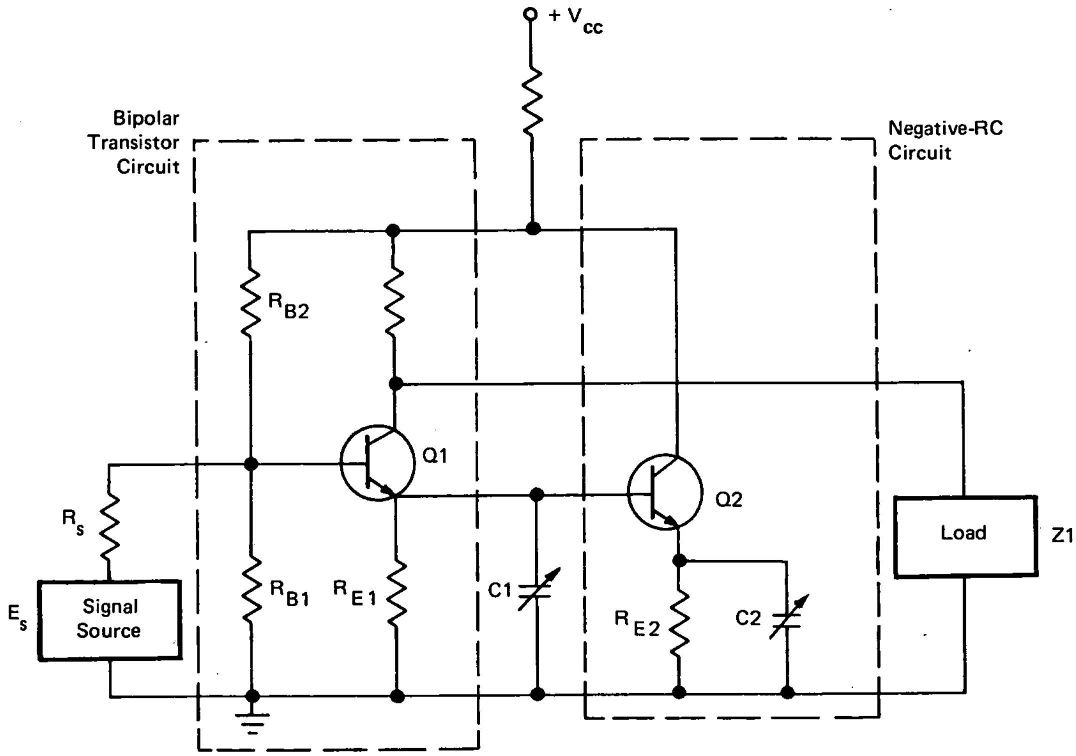

Figure 3. Active Tuning Circuit

the oscillation frequency when the coupling capacitance C1 is zero. The advantages of this circuit include:

a. It may be manufactured by standard microelectronic techniques;
b. It has a very low noise factor;
c. It has a better center-frequency stability over a broad temperature range than conventional RF circuits;
d. It can be tuned and combined for many uses, such as RF preamplifiers, oscillators, mixers and others; and
e. The input and output impedances are so close that input-output matching networks are not necessary.

Notes:

1. Four complete FM receivers have been constructed using this one basic circuit (a 50 MHz, a 100 MHz, and two 401.5 MHz circuits).
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Code 207.1
   Greenbelt, Maryland 20771
   Reference: TSP73-10334

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,693,105). Inquiries concerning nonexclusive or exclusive license for its development should be addressed to:

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